Multi-Element Multihop Backhaul Reconfigurable Antenna NEtwork

The Multi-Element Multihop Backhaul Reconfigurable Antenna Network (MEMBRANE) project aims to bring an efficient wireless backhaul design as an alternative technology to serve wireless broadband networks in cases where a wired backhaul would be more costly to access and/or would take longer to deploy.

At A Glance: *MEMBRANE*

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Duration: *January 2006-June 2008*
Total Cost: *€4.3m*
EC Contribution: *€2.8m*

Main Objectives:

The ongoing proliferation of wireless broadband data services is expected to lead to increased needs on the side of the backhaul network, which transports data between the access network and the wired Internet, as well. The typical upgrade of wired lines to high-speed fibre networks is not always an available or economically attractive solution. In such cases, wireless alternatives could offer an appealing alternative. We propose the design of efficient wireless backhaul networks that meet the Quality of Service (QoS) demands of high speed access wireless networks, thus providing a technology shortcut that will help satisfy the social need for broadband data anytime anywhere in a much more expeditious way.

Given the need for an efficient wireless backhaul network, its successful deployment necessitates careful design and this is likely to require nothing short of a number of technological breakthroughs. The main envisioned requirements of such backhaul network are the following:

- **Quality of Service**:
  - Throughput performance: in order to satisfy the growing demands of data throughput of wireless access networks, a primary target of the corresponding backhaul network is its high capacity.
  - Delay performance: several applications have stringent delay requirements whose satisfaction is critical to acceptable user experience.
  - Coverage: especially in the case of remote or isolated areas, it is important that the backhaul network has enough range to reach the end nodes.
  - Overall capacity: obviously, while providing performance and coverage, being a wireless network, such a backhaul has to be able to provide sufficient capacity from a system point of view.
- **Reconfigurability**: another important feature of wireless networks is that they must be capable of reconfiguring themselves, in terms of network topology, traffic flow and propagation conditions.
- **Heterogeneity**: since wireless broadband access networks employ several technologies, it is important that the proposed backhaul network is capable of matching these heterogeneous networks.
- **Ubiquity**: The addition of efficient wireless backhaul will go a long way in ensuring the delivery of wireless broadband access to the entire addressable population in a ubiquitous manner.
- **Openness**: from the operator's point of view, it is important that the developed concepts meet the requirements of double-openness, i.e., standard interfaces and multi-supplier technologies.

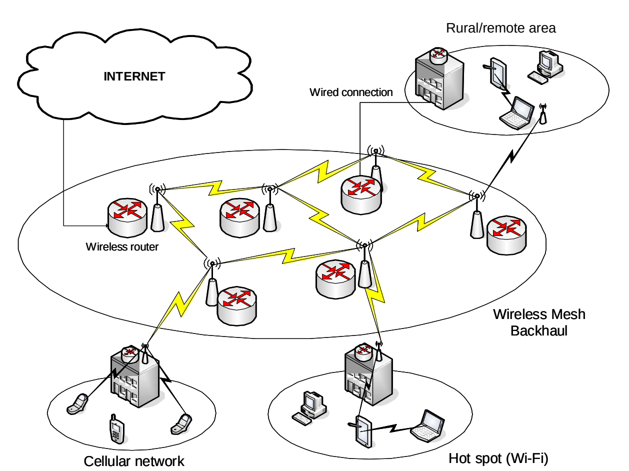
Enabling Technologies

To satisfy the above requirements, a number of enabling technologies will be exploited that have the potential, when combined, to deliver the expected performance:

Multi-hopping, i.e. the use of relays between the end user and the end node, is primarily motivated by the low power and the low heights of the access (AN) and relay nodes. Clearly, in low power transmissions, multi-hopping helps increase the *range*. Moreover, since low height ANs are likely to be surrounded by several obstacles, multi-hopping helps avoid the problem via multiple links that are more likely to have LOS between them.

Intelligent Antennas (IA) such as beamforming (BF) and MIMO transmission can offer improved *throughput* and range. Moreover, through their added ''spatial'' degrees of freedom, they can also reduce interference from adjacent links. Reconfigurable IA algorithms can be designed that match in the best possible way a given propagation environment, *boost throughput* and reduce interference thus improving overall end-to-end performance. The combination of multihop with multiple antennas is a field that is virtually unexplored and *it will constitute a major innovation in MEMBRANE*.

MEMBRANE Wireless Mesh Reference Architecture.



Opportunistic routing & scheduling targets primarily the satisfaction of the network's *delay* requirements; when combined with IA it can also increase the end-to-end throughput. By opportunistic routing and scheduling we refer to routing and scheduling policies that take into account the *network context*. By this we mean the quality of different links, the data traffic needs on different ANs, the capacity of different relays, the packet activity of different links, etc. Another potential gain of multi-antenna multihop mesh networks is their potential for *significantly improved QoS via combined opportunistic routing and spatial data multiplexing.*

Technical Approach

The MEMBRANE project is structured in the following workpackages:

WP1: Project Management

WP2: Problem definition and scenarios

WP3: Theoretical multihop network performance analysis

WP 4.1: Multi-antenna link signalling and routing

WP 4.2 Routing, scheduling and power control for wireless backhaul network optimisation

WP4.3 Wireless multihop backhaul IP network design

WP5.1 MEMBRANE System Simulation Platform

WP5.2 MEMBRANE Prototype

WP6.1: Overall performance evaluation

WP6.2: Exploitation and Dissemination

Anticipated outcome and impact

The studies within MEMBRANE will:

- Enhance the understanding of the fundamental capacity limits of multiple antenna multihop networks.
- Provide optimal network topologies, in demanding propagation conditions and under low power or low cost constraints.
- Develop efficient, reconfigurable routing and scheduling algorithms that maximize QoS, power utilization and service fairness. The joint routing and scheduling algorithms will represent a new approach to routing and scheduling, which fully exploits the knowledge of condition of radio links along any given route for the best route selection and scheduling performance in multihop wireless networks.
- Develop reconfigurable smart antenna techniques for throughput maximization and delay minimization.
- Invent new techniques for efficient resource utilization by combining intelligent antenna, routing and scheduling techniques.
- Provide proofs-of-concept of the developed network design and algorithms via a comprehensive system-level evaluation platform and proof-of-concept demonstration.
- Give recommendations for next generation air interface design for the backhaul network, that are based on cross-layer optimized design and its novel spatial/temporal/opportunistic routing and scheduling policies.